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DIABASE OF THE COBALT DISTRICT, ONTARIO

REGINALD E. HORE

Here referred to is that portion of the District of Nipissing from Lake Temagami north to the Hudson Bay watershed, an area about eighty miles square. A general description of the region has recently[1] been given by the writer, and some of the geological features are outlined in the following table.

In this area are many recently discovered deposits of native silver, the most important being at Cobalt. All the deposits are in pre-Cambrian rocks, most of the valuable ones in Huronian conglomerate, and a few in Keewatin greenstones and Keweenawan diabase. In all cases the deposits are closely associated with masses of diabase, and are probably genetically connected with them.

In the following description of the diabase, mention is also made of minor intrusions and fissure-fillings, it being suggested that all or part may have originated in the diabase magma and are an expression of the phenomena which occurred on cooling.

The diabase masses.—In almost every township there are outcrops of quartz-diabase. Many of the exposed masses are very irregular in outline, while others show decidedly elongated forms with the longer dimension generally north and south. In several instances the diabase conforms to, and apparently has had its shape determined by, the bedding planes in intruded shales; but some similar masses show in places more stocklike characters, intruding the shales at high angles and forming schistose and slaty contact zones. In rocks other than shales the diabase shows less pronounced sheetlike forms, and appears rather as small stocks and dikes.

General character of the diabase.—The greater part of the diabase masses is of gray to dark-gray color, of medium grain, and with ophitic texture. The specific gravity is about 3.00. The rock is composed chiefly of gray or greenish sodi-calcic feldspar and dullbrown pyroxenes. Biotite and black iron oxides are generally visible. Quartz is generally present; but often in small quantity intergrown with feldspar and not always visible to the naked eye. In some specimens there is a decided pink color due to the presence of pink feldspar, and in these portions quartz is more prominent, and grains of pyrite and chalcopyrite are frequently visible. In rarer instances the rock is almost completely made up of feldspar and quartz with but small amounts of ferromagnesian minerals. In some of the masses there are numerous small aplitic veins closely related to the quartz-feldspar portions just mentioned but practically free of ferromagnesian minerals.

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[1] R. E. Hore, "Silver Fields of Nipissing," Toronto meeting, Canadian Mining Institute, 1910.

Microscopic character.—Specimens of medium-grained gray diabase from all parts of the district show very similar composition. Plagioclase feldspars and pyroxenes are the only minerals present in large quantity. Iron ores are always present in small quantity, and filling the interstices is a micrographic intergrowth of feldspar and quartz.

In thin sections the fresh rock is nearly colorless. Generally the feldspar is somewhat clouded with alteration products, and the pale-brown tinted pyroxene has usually some greenish uralitic or chloritic spots. Angular particles of black ilmenite are generally partially altered to grayish-white leucoxene.

Other minerals sometimes found include biotite, hornblende, quartz, apatite, olivine, chalcopyrite, and pyrite. Among secondary minerals are chlorite, sericite, leucoxene, sphene, limonite, epidote, and carbonates.

Pyroxene.—The common pyroxene is of very pale brownish color. Rarely one finds decided violet-tinted varieties. The shape is irregular and has evidently been determined by the nature of the spaces left after most of the feldspar had crystallized. Less commonly the pyroxene and feldspar crystal boundaries are equally well developed. The size varies greatly in slices from different specimens; commonly they are from 2 to 5 mm. but some of coarser grain show blades of pyroxene from 5 to 20 mm. in length. These large crystals are usually twinned and show marked diallagic striae and they are generally somewhat altered to a greenish fibrous hornblendic substance. Some slides show numerous grains which have the optical properties of rhombic pyroxenes; but their composition has not been definitely determined.

Feldspar.—The feldspars generally show green or gray tints and occasionally there is present a pink-colored variety. The measurement of angles of extinction by the Michel-Levy method indicates that much of the feldspar is of highly calcic varieties, and chemical analysis of the rock indicates the same. The pink-colored feldspar is more highly sodic, and in aplitic veins showing no ferromagnesian mineral has the composition of albite. The lime-soda feldspars are rarely fresh, partial alterations being indicated by white opaque portions and small grains and flakes of brightly polarizing minerals, the exact nature of which has not been definitely determined. Small grains of epidote are characteristic components of the aggregate. The sodic feldspars, unlike the calcic, are very free from evidences of decomposition.

Ilmenite occurs in typical forms showing the skeleton-like arrangement, and alteration along crystallographic directions to leucoxene. The powdered mineral is not noticeably attracted by the magnet, but large rock masses influence the magnetic needle.

Quartz occurs frequently intergrown micrographically with feldspar, and in the gray diabase is rare otherwise. In the aplitic veins it is often found with the feldspar in typical panidiomorphic structure.

Biotite occurs frequently as dark-brown pleochroic plates, which are conspicuous in the powdered rock, though their weight is comparatively insignificant.

Hornblende.—A green hornblende is a common constituent, especially in specimens which show alterations in the pyroxenes. It is usually in fibrous aggregates and is probably secondary. Some few specimens in which pyroxenes are quite fresh show well-formed green hornblende which is probably primary. A partial analysis of the red rock from James Township (Anal. 4) showed less than 1 per cent total alkalies, and as part at least of this was due to incomplete separation from feldspars, the hornblende in this sodic portion is not an alkali variety.

Olivine is typically absent in the large diabase masses but occurs as yellowish-green grains in varieties containing no micropegmatite. In small intrusives olivine is a common constituent.

Chemical composition of the diabase.—The examination of exposures in all parts of the district proves that most of the diabase is of the medium-grained gray type and the microscopic examination shows that there is great uniformity in the mineral composition of this rock. Chemical analysis of specimens from one locality may therefore be taken as typical of many square miles of the diabase. The following analyses (Nos. 1, 2, and 3) are of specimens taken from the diabase in the silver-producing area at Cobalt. All three specimens were taken a few inches from the surface and in them are evidences of alteration—especially in the feldspars. In reddish portions of the diabase, analysis (see No. 4) shows a higher percentage of silicon and a marked increase in sodium, and microscopic examination of such specimens shows a higher percentage of feldspar-quartz intergrowths and less of pyroxene.

Diabase dikes.—In the diabase there are dikes and veins of various types. The darker-colored dikes are usually very fine grained, distinctly ophitic in texture, high in content of iron oxides, and frequently show olivine. They vary in width from a few inches to several feet. Dikes more than one hundred feet wide are usually very similar in composition to the larger masses. A comparatively small number of the dark-colored dikes show little or no olivine and are characterized by large phenocrysts of white or gray plagioclase among which labradorite has been recognized.

The sodic aplitic veins.—Lighter-colored dikes and veins are in some cases composed almost entirely of sodic feldspars and quartz. Most of the other fillings have quartz or calcite as the chief mineral, and where both are present the quartz is distinctly older than the calcite. These light-colored fissure-fillings are in many cases very irregular in shape, but are generally less than three feet in width. They have various marginal characters. Some are not well marked off from the diabase, grading into it by an interlocking of crystals that leaves no definite contact, thus closely resembling the "contemporaneous veins" of Teall and Geikie. Others show decided lines of demarkation and a few have a soft green aphanitic selvage. In James Township there are numerous such aplitic veins, usually but a few inches in width and commonly gray, flesh-colored, or greenish gray. The former are chiefly composed of feldspar and quartz, while the

	1	2	3	4	5	6	7	8
SiO_2	50.69	50.80	50.48	52.25	73.07	78.28	72.33	58.84
Al_2O_3	16.11	19.42	17.03	17.97	14.88	12.00	12.99	11.24
Fe_2O_3	0.70	0.97	1.25	0.81	0.04	....	none	....
FeO	7.05	6.67	7.81	8.89	2.93	1.19	2.50	0.47
MgO	8.20	5.78	9.32	6.46	1.30	0.37	0.97	0.35
CaO	12.09	12.68	10.96	7.27	0.66	0.29	1.73	12.17
Na_2O	1.78	1.60	1.95	3.61	6.17	6.89	7.60	6.91
K_2O	0.78	0.37	0.24	1.71	0.46	none	none	none
H_2O+	1.65	0.86	0.82	1.80	0.90	0.61	1.09	0.40
H_2O-	0.16	0.25	0.22	0.04				
CO_2	....	....	....	....	....	none	1.00	9.84
TiO_2	0.53	0.43	p.n.d.	p.n.d.	0.41	0.34	0.74	0.26
CoO, NiO	0.11	0.01	0.04	....	none	....	....	....
S	0.07	....	....	....	....	....	....	..13
Sum	99.82	99.84	100.12	100.81	100.82	99.97	100.95	100.61
Rock name	Quartz-diabase	Quartz-diabase	Quartz-diabase	Quartz-diorite	Aplitic soda granite	Aplitic soda granite	Aplitic soda granite	Aplitic soda granite
Locality	Silver Bar Mine, Cobalt, Ont.	Kerr Lake Mine, Cobalt, Ont.	University Mine, Cobalt, Ont.	James Twp., Nipissing, Ont.	University Mine, Cobalt, Ont.	James Twp., Nipissing, Ont.	University Mine, Cobalt, Ont.	James Twp., Nipissing, Ont.
Analyst	R. E. Hore	R. E. Hore	R. E. Hore	R. E. Hore	R. E. Hore	N. L. Bowen	N. L. Bowen	N. L. Bowen

greenish ones contain a fibrous chlorite. Frequently the aplites have a considerable percentage of finely crystalline calcite, and small crystals of titantite and grains of epidote are common. The quartz and feldspar are usually in equidimensional grains as typical in aplites, while occasionally there are micrographic intergrowths, and in some specimens rounded grains of feldspar in a matrix of later-formed quartz. Analysis by N. L. Bowen of a specimen from one of these veins is given in the table on p. 275 (anal. No. 6).[1]

On the property of the University Mine in Coleman Township is a larger fissure-filling, exposed at intervals for eight hundred feet, and in places over fifty feet wide. Analyses of specimens of this vein are given in Columns 7 and 8. The specimen No. 7 is a fine-grained gray soda granite taken from the wide part of the vein. The specimen No. 8 was taken about three hundred feet from No. 7, and is finer in grain and free from carbonates. Portions of the rock contain a high percentage of calcite, which fills interstices between the earlier-formed feldspar and quartz.

Quartz and calcite veins.—The most common type of minor fissure-fillings is composed of white quartz. Chlorite and fibrous amphibole are common constituents and pyrite, chalcopyrite, and galena are frequently present. In some of the quartz veins there is considerable calcite filling interstices between well-formed quartz crystals.

Relation of the diabase and sodic aplitic veins.—In some large sills there are portions, one to two hundred feet from the bottom, which are pink, coarse grained, and more highly sodic than the gray, medium-grained, main mass, into which they pass by insensible gradations. Similar pink-colored rocks occur as irregular-shaped masses distinctly marked off from the gray diabase. The microscopic examination shows that the pink-textured portions have a higher percentage of those minerals which were last to crystallize in the gray diabase. The aplitic veins are composed almost entirely of the chief of these last-formed minerals—sodic feldspar and quartz.

There is a lack of evidence which would indicate any extensive fusion and absorption of the intruded rocks. Xenoliths are not found. The pink rock has not a composition intermediate between the gray diabase and the intruded shales. It seems probable therefore that the variations in composition are the natural consequence of the cooling of a molten magma whose composition was near that of the gray diabase, except that the latter does not contain the same proportion of volatile constituents.

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[1] N. L. Bowen, *Canadian Mining Journal*, April 15, 1909; see also *Bulletin of Canadian Mining Institute*, December, 1909.

The aplitic veins seem to have been formed by the last secretions from the diabase magma, filling fissures which developed after most of the mass had solidified, while the pink-colored diabase and gabbro masses represent the solidification from the molten magma at an intermediate stage in a process of differentiation.

The irregular pink-colored patches and streaks were probably intruded earlier into hot but viscous portions of the cooling masses. In these cases it appears that there has been differentiation in the diabase magma but not *in situ.* Some other pink portions of the thick sills are probably the result of differentiation *in situ.*

ROCKS OF THE NIPISSING SILVER FIELDS

CENOZOIC	*Recent:*	Clay, marl, peat.
	Pleistocene	(1) Coarse unstratified material—sand, gravel, and bowlders; (2) Stratified clay with some sand.
	Great unconformity	
PALEOZOIC	*Silurian:*	Grey limestone with some interbedded greenish shales, and at the base an arenaceous conglomerate. Correlated with Niagara of New York state.
	Great unconformity	
ALGONKIAN	*Keweenawan:*	Igneous intrusives only. Chiefly quartz diabase and quartz gabbros with acid differentiation products. Some olivine diabase and diabase porphyrite dykes.
	Igneous contact	
	Huronian:	Sedimentary rocks only.
		(1) An upper series. Probably equivalent to Middle Huronian of Lake Superior. Chiefly feldspathic quartzite with some conglomerate.
	Slight unconformity	
		(2) A lower series. Probably equivalent to Lower Huronian of Lake Superior. Chiefly greywacke, shale, conglomerate, and feldspathic quartzite. The conglomerate pebbles are mostly of holocrystalline igneous rocks, the matrix greywacke and grey shale.

		The rocks are seldom schistose except as the result of contact metamorphism.
	Great unconformity	
ARCHEAN	*Laurentian:*	Igneous intrusives only. Holocrystalline light-colored siliceous rocks. Chiefly granites, diorite, syenites, and gneisses.
	Igneous contact	
	Keewatin:	Igneous and sedimentary rocks. All are much metamorphosed, and many schistose. The relative age of the igneous and sedimentary rocks is doubtful; but the iron formation is probably younger than much of the igneous portion. The agglomerates were probably contemporaneous with some of the non-clastic volcanic rocks, and may be contemporaneous with the other sediments. The igneous rocks are chiefly of *extrusive* types. *Extrusives:* (1) Dark-colored basic rocks—basalts—mostly with composition and texture of altered diabases. (2) Light-colored siliceous rocks—felsites and felsite porphyries—mostly quartz porphyries which have been altered to sericite schists. *Intrusives:* (1) Basic rocks, mostly diabase and gabbro. (2) Siliceous rocks, mostly quartz porphyries and porphyrites. *Sediments:* (1) The iron formation—chert, jasplite, carbonates, slates, and green schists. (2) Fragmental volcanic rocks—a grey felsite agglomerate.